

CHISUM ON PATENTS

*A Treatise on the Law of Patentability,
Validity and Infringement*

VOLUME 1

DONALD S. CHISUM
Seattle, Washington, USA
<http://www.chisum.com>

2006

Filed Through:

RELEASE NO. 105, SEPTEMBER 2006

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Library of Congress Card Number: 78-70641

ISBN: 0-8205-1525-6

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Originally published in: 1978

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(Rel. 105-9/2006 Pub.00525)

in the final product after mixing.” She noted testimony by a patent practitioner who helped prosecute the patent that “claiming the composition in terms of amounts of additives is ‘a typical way it is done in connection with motor oil additives.’”³⁹ An employee of the accused infringer, when asked “to determine whether certain of its products infringed the European counterpart of” the patent in suit “performed the analysis by comparing the starting ingredients, not the final or intermediate products.”⁴⁰ Another employee, a lubricant formulator, “testified (although not in the specific context of interpreting claim language) that her concern as a formulator is ‘what goes in the pot.’”⁴¹ Finally, the patent examiner “found nothing technically wrong with the claim as a list of additives.”⁴²

[3] Definition of a Manufacture

Professor Robinson viewed “manufacture” as a “comprehensive class of inventions” that included “every article devised by man except machinery upon the one side, and compositions of matter and designs upon the other.”⁴³ Thus, it is the residual class of “product” patent—encompassing all man-made items not found in substantially the same form in nature that are neither machines nor compositions of matter.

Robinson’s approach was adopted in a number of court decisions⁴⁴ and could today be considered the accepted position but for the decision of the Supreme Court in *American Fruit Growers, Inc. v. Brogdex Co.* (1931).⁴⁵

[a] **Borax-Impregnated Orange Case: *American Fruit Growers v. Brogdex* (1931).** In *American Fruit Growers, Inc. v. Brogdex Co.* (1931),⁴⁶ the Supreme Court addressed a patent that claimed “fresh citrus fruit of which the rind or skin carries borax in amount that is very small but sufficient to render the fruit

³⁹ 64 F.3d at 1567, 35 USPQ2d at 1812.

⁴⁰ *Id.*

⁴¹ *Id.*

⁴² 64 F.3d at 1568, 35 USPQ2d at 1812.

⁴³ 1 W. Robinson, *The Law of Patents for Useful Inventions* 270 (1890).

⁴⁴ *Johnson v. Johnston*, 60 F. 618 (W.D. Pa. 1894); *Sammons & Sons v. Ladd-Fab, Inc.*, 221 USPQ 737 (Calif. Ct. App. 1982).

See also *In re Bergy*, 596 F.2d 952, 201 USPQ 352 (CCPA 1979), *aff’d sub. nom. Diamond v. Chakrabarty*, 447 U.S. 303, 206 USPQ 193 (1980), discussed § 1.02[7][d]; *Binney & Smith Co. v. United Carbon Co.*, 125 F.2d 255, 52 USPQ 205 (4th Cir. 1942), *rev’d on other grounds*, 317 U.S. 228 (1943); *American Patent Dev. Corp. v. Carbice Corp.*, 38 F.2d 62, 64, 4 USPQ 141 (2d Cir. 1930), *rev’d on other grounds*, 283 U.S. 27 (1931).

⁴⁵ *American Fruit Growers, Inc. v. Brogdex Co.*, 283 U.S. 1 (1931).

⁴⁶ *American Fruit Growers, Inc. v. Brogdex Co.*, 283 U.S. 1 (1931).

resistant to blue mold decay.”⁴⁷ The Court held that an orange impregnated with borax is not a “manufacture” within the meaning of the Patent Act. However, the reasoning in the Court’s opinion is very weak. It quotes a dictionary definition of “manufacture” as “the production of articles for use from raw or prepared materials by giving to these materials new forms, qualities, properties, or combinations.”⁴⁸ It then reasons that “the addition of borax to the rind of natural fruit does not produce from the raw material an article for use which possesses a new or distinctive form, quality, or property.”⁴⁹ “There is no change in the name, appearance, or general character of the fruit. It remains a fresh orange, fit only for the same beneficial uses as theretofore.”⁵⁰ This argument is simply erroneous as a matter of fact. An impregnated orange may look the same and taste the same as a natural orange, but it is not chemically the same. An impregnated orange is also fit for new “beneficial uses,” if the patentee’s statements are to be believed. It is a product that can be shipped and stored with less danger of blue mold.

The Court also relied on two of its prior decisions, neither of which concerned patent law. *Hartranft v. Wiegmann* (1887)⁵¹ concerned a tariff statute that imposed a duty of 35% on “shells, manufactures of” but exempted “shells of every description, not manufactured.” The court held that shells which were cleaned with acid and polishing on an emery wheel were not manufactured because they had no “distinctive name, character, or use” different from an ordinary shell.

Aneheuser-Busch Brewing Ass’n v. United States (1908)⁵² concerned another tariff statute which allowed a rebate of duties paid on imported materials “used in the manufacture of articles manufactured in the United States,” which articles are then exported. The Court held that corks imported, cleaned, treated, and then inserted in bottles of beer for export were not such materials: “Manufacture implies a change, but [not] every change is . . . manufacture There must be transformation A cork put through the claimant’s process is still a cork.”⁵³

Neither decision should properly be considered a precedent for the meaning of “manufacture” in patent law. The purposes of tariff and patent statutes are, of course, radically different. It is clearly fallacious to assume that a single term such

⁴⁷ U.S. Pat. No. 1,529,461.

⁴⁸ 283 U.S. at 11.

⁴⁹ 283 U.S. at 11.

⁵⁰ 283 U.S. at 12.

⁵¹ *Hartranft v. Wiegmann*, 121 U.S. 609 (1887).

⁵² *Aneheuser-Busch Brewing Ass’n v. United States*, 207 U.S. 556 (1908).

⁵³ 207 U.S. at 206–207.

as “manufacture” must have a single meaning in law.

It must be concluded that the *American Fruit Growers* treatment of the meaning of “manufacture” is of little or no precedential value.⁵⁴ No patent law policy is served by requiring that a product differ in name, appearance, or general character from natural products or existing products in order to qualify as a “manufacture.”⁵⁵ The presence or absence of a “new or distinctive form, quality or property” is an issue properly relevant to the statutory standards of novelty and nonobviousness.

In *Diamond v. Chakrabarty*, (1980),⁵⁶ the Court quoted the *American Fruit Growers* definition but apparently found it compatible with a broad view of the concept of a manufacture. In holding that a genetically-altered living microorganism qualifies as patentable subject matter, the Court cited legislative history accompanying the 1952 Act that suggested that statutory patentable subject matter would include “anything under the sun that is made by man.”

Lower court and administrative decisions since *American Fruit Growers* distinguish its holding.⁵⁷

Steinfur Patents Corp. v. William Beyer, Inc. (1932)⁵⁸ concerned an improvement in the art of bleaching and dyeing furs. A process patent claimed a method of treating unbleached skins, bleaching them and then dyeing the bleached skins. The process allowed use of cheaper dark-colored furs to make the more desirable white and light-colored furs. A product patent claimed skins that had been impregnated with the protective solution but not bleached, skins that had been bleached after impregnation, and skins that had been impregnated, bleached and dyed according to the process. The defendant urged that the described skins did not constitute “manufactures,” citing *American Fruit Growers*. The court distinguished *American Fruit Growers* and upheld the patent.

“In none of the three stages sought to be protected by the present patent were the dressed skins in their natural state. While it was true of the orange that impregnation of its rind with borax only protected the natural article against deterioration by mold and gave it no new beneficial uses, the same

⁵⁴ The court held as an alternative holding that the patent was invalid for lack of novelty. This was a much sounder basis of decision.

⁵⁵ For a discussion of “products of nature,” see § 1.02[7].

⁵⁶ *Diamond v. Chakrabarty*, 447 U.S. 303, 206 USPQ 193 (1980), discussed § 1.02[7][d].

⁵⁷ *Steinfur Patents Corp. v. William Beyer, Inc.*, 62 F.2d 238 (2d Cir. 1932), discussed below; *Ex parte Mowry*, 110 USPQ 389 (Pat. Off. Bd. App. 1955), discussed below.

But cf. *Bayer Ag v. Housey Pharmaceuticals, Inc.*, 340 F.3d 1367 (Fed. Cir. 2003), discussed below and § 16.02[6][d][iv][B].

⁵⁸ *Steinfur Patents Corp. v. William Beyer, Inc.*, 62 F.2d 238 (2d Cir. 1932).

cannot be said of impregnation of the unbleached skin with ferrous sulphate. By such impregnation the skin attains a new quality which gives it a new beneficial use; it fits it to be used for bleaching by a method which could not without such impregnation be successfully employed. An orange has the same use whether or not impregnated with borax. A fur skin unimpregnated with ferrous sulphate cannot be used in the same way as one which has been so impregnated."⁵⁹

Similarly, *Ex parte Mowry* (1955)⁶⁰ concerned a claim for "erosion-stable soil which comprises a natural soil containing on the surface thereof a substantially continuous film of a water-soluble polymer" of a specified compound. The Board held that such a claim was for a "manufacture" and distinguished *American Fruit Growers*. "[H]ere the polymer is adsorbed by electrolytic phenomena on the soil particles and the individual soil particles are chemically bound to form an erosion resistant but water pervious layer on the surface of the soil. Such soil is quite distinct from untreated soil." The Board also noted that "[W]e do not find anything in the definition of manufacture which requires that it be transportable or packaged as an article of commerce."⁶¹

[b] "Kits" with Components for Assembly. In *In re Venezia* (1976),⁶² the Court of Customs and Patent Appeals held that a claim for a "kit having component parts capable of being assembled in the field" constituted patentable subject matter as a "manufacture."

"To hold that the words 'any manufacture' exclude from their meaning groups or 'kits' of interrelated parts would have the practical effect of not only excluding from patent protection those 'kit' inventions which are capable of being claimed as a final assembly . . . but also many inventions such as building blocks, construction sets, games, etc., which are incapable of being

⁵⁹ 62 F.2d at 240.

⁶⁰ *Ex parte Mowry*, 110 USPQ 389 (Pat. Off. Bd. App. 1955).

See also *Ex parte Shepherd*, 185 USPQ 480, 485 (Pat. Off. Bd. App. 1974).

⁶¹ 110 USPQ at 390.

⁶² *In re Venezia*, 530 F.2d 956; 189 USPQ 149 (CCPA 1976).

See also *Ex parte Sudan*, 224 USPQ 614, 615 (Bd. App. 1983) (Claim to "two container pack" of ingredients for mixing to form a foam is not improper; "The difference that in *Venezia* the kit, when assembled, may readily be disassembled whereas here the foam produced cannot be reformed to its original constituent parts palpably is a difference irrelevant insofar as compliance with Section 112 of the Statute is concerned."); *Ex parte Wolters*, 214 USPQ 735 (PTO Bd. App. 1979) (rejection of claim to "test pack" of several antibodies as not for an "integral structural unit" reversed).

Compare *In re Ngai*, 367 F.3d 1336 (Fed. Cir. 2004), discussed § 1.02[4] (kit comprising instructions for carrying out a method and a suitable reagent; anticipation by prior art showing kit with different instructions and the reagent).

SEISMIC DATA PROCESSING

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Post Office Box 702740/ Tulsa, OK 74170-2740**

ISBN 0-931830-41-9 (Series 1)
ISBN 0-931830-40-0 (Volume 2)

Library of Congress Catalog Number: 87-061718

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Published 1987 by
Society of Exploration Geophysicists
P. O. Box 702740
Tulsa, OK 74170-2740

Second printing 1988, Third printing 1988,
Fourth printing 1989, Fifth printing 1991,
Sixth printing 1993.

Printed in the United States of America

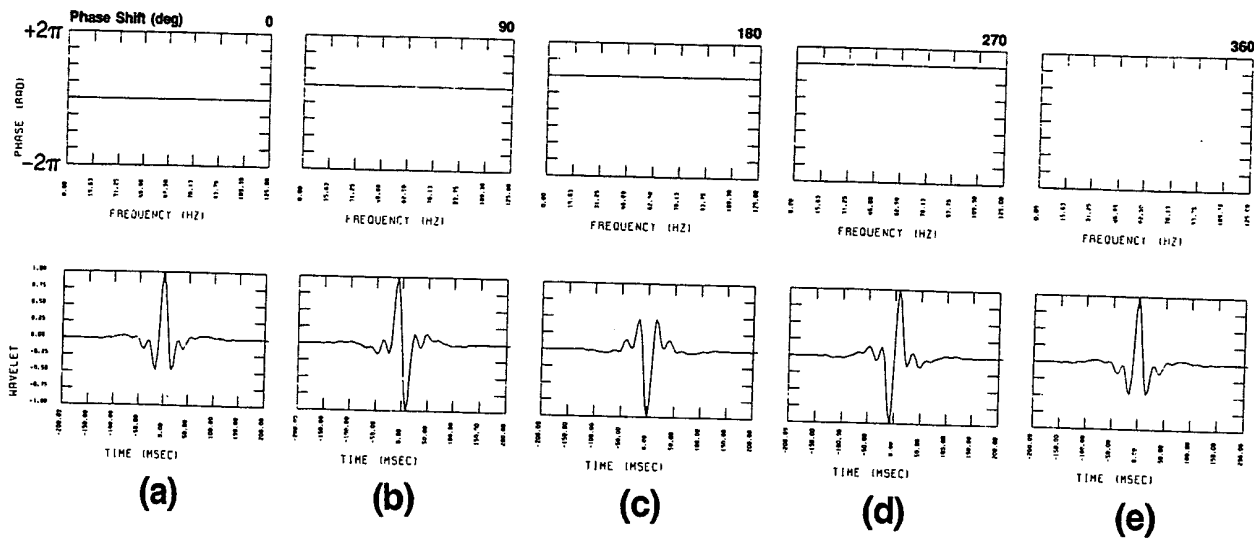


FIG. 1-15. Starting with the zero-phase wavelet (a), its shape is changed by applying constant phase shifts. A 90-degree phase shift converts the zero-phase wavelet to an antisymmetric wavelet (b), while a 180-degree phase shift reverses its polarity (c). A 270-degree phase shift reverses the polarity, while making the wavelet antisymmetric (d). Finally, a 360-degree phase shift does not modify the wavelet (e).

effect of the two now is considered. The phase spectrum is a function defined as $a + b \cdot \text{frequency}$, where a is the constant phase shift and b is the slope of the linear phase shift. Figure 1-16 shows the results of applying a 90-degree constant phase plus a linear phase component to the sinusoids in Figure 1-11. The zero-phase wavelet with the same amplitude spectrum as that in Figure 1-11 was shifted in time by -0.2 s because of the linear phase shift, and converted to an antisymmetric form because of the constant 90-degree phase shift.

Other variations in phase spectrum are shown in Figure 1-17. The zero-phase wavelet (Figure 1-17a) can be modified to different shapes simply by changing the phase spectrum. It can be modified so much that it may not resemble the original wavelet shape as illustrated by the last example (Figure 1-17d). By keeping the amplitude spectrum unchanged, the wavelet shape can be changed by modifying the phase spectrum.

1.2.3 Time-Domain Operations

Consider a reflectivity sequence represented by the time series $(1, 0, \frac{1}{2})$. Also consider an impulsive source that causes an explosion at $t = 0$ with an amplitude of 1. The response of the reflectivity sequence to an impulse is called the *impulse response*. This physical process can be described as follows:

Time of Onset	Reflectivity Sequence	Source	Response
0	1 0 $\frac{1}{2}$	1	1 0 $\frac{1}{2}$

One unit time later, suppose that the impulsive source generates an implosion with an amplitude of $-\frac{1}{2}$. This

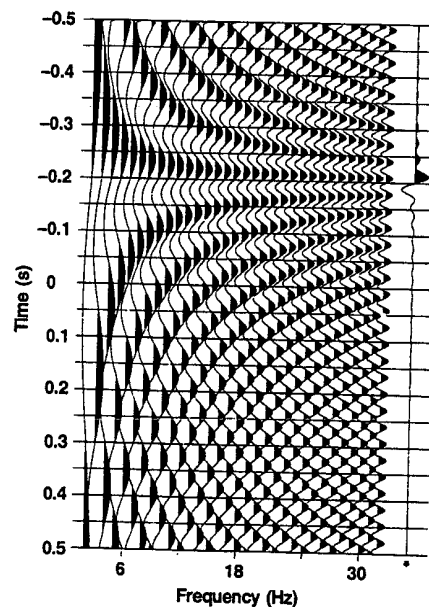


FIG. 1-16. A linear (Figure 1-12) combined with a constant phase shift (Figure 1-14) results in a time-shifted antisymmetric wavelet. The wavelet is represented by the trace on the right (denoted by an asterisk).

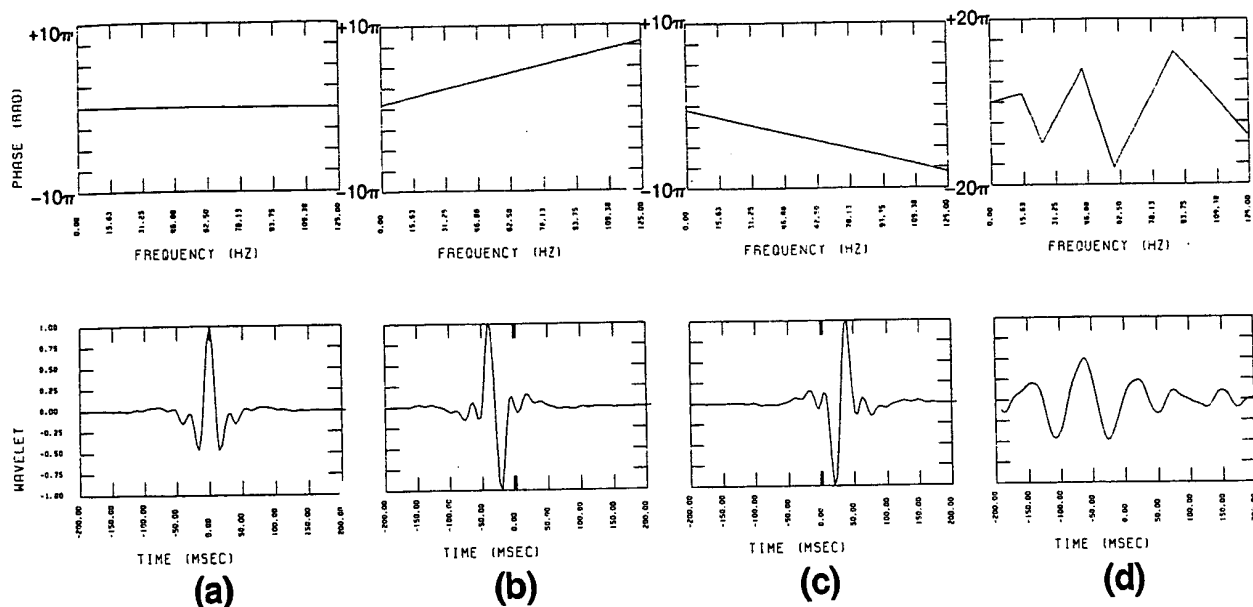


FIG. 1-17. The shape of a zero-phase wavelet (a) can be modified by introducing a nonzero-phase spectrum of any form as in (b), (c), (d).

process is described as:

Time of Onset	Reflectivity Sequence	Source	Response
1	1 0 $\frac{1}{2}$	$-\frac{1}{2}$	$-\frac{1}{2}$ 0 $-\frac{1}{4}$

Note that the response is the reflectivity sequence scaled by impulse strength. Since a general source function is considered to be a sequence of explosive and implosive impulses, the individual impulse responses are added to obtain the combined response. This process is called linear superposition and is described in Table 1-1.

In Table 1-1, the asterisk denotes *convolution*. The response of the reflectivity sequence $(1, 0, \frac{1}{2})$ to the source wavelet $(1, -\frac{1}{2})$ was obtained by convolving the two series. This is done computationally as shown in Table 1-2.

A fixed array is set up from the reflectivity sequence. The source wavelet is reversed (folded) and moved (lagged) one sample at a time. At each lag, the elements that align are multiplied and the resulting products are summed. The mechanics of convolution are described in Table 1-3. The number of elements of output array $c(k)$ is given by $m + n - 1$, where m and n are the lengths of the operand array $a(i)$ and the operator array $b(j)$, respectively.

When the roles of the arrays in Table 1-2 are interchanged, the output array in Table 1-4 results. Note that the output response is identical to that in Table 1-2. Hence, it does not matter which array is fixed and which is moved as the convolution is performed.

Seismic processing often requires measurement of the similarity or time alignment of two traces. *Correlation* is another time-domain operation that is used to make such measurements. Consider the following two wavelets:

Wavelet 1: $(2, 1, -1, 0, 0)$

Wavelet 2: $(0, 0, 2, 1, -1)$

Although these wavelets are identical in shape, wavelet 2 is shifted by two samples with respect to wavelet 1. The time lag at which they are most similar can be determined. To do this, perform the operation on wavelet 1 as described in Table 1-3 without reversing wavelet 2 (omit Step 0). This is *crosscorrelation* and the result is shown in Table 1-5. Crosscorrelation measures how much two time series resemble each other. Crosscorrelation of a time series with itself is known as *autocorrelation*.

From Table 1-5, note that maximum correlation occurs at lag -2 . This suggests that if wavelet 2 were shifted two samples back in time, then these two wavelets would have maximum similarity.

Table 1-6 shows the crosscorrelation values that result when the arrays are interchanged. This time the maximum correlation occurs at lag 2. Thus, if wavelet 1 were shifted two samples forward in time, then these two wavelets would have maximum similarity. Also note that, unlike convolution, crosscorrelation is not commutative; i.e., the output depends on which array is fixed and which is moving (compare the results listed in Tables 1-5 and 1-6).

Table 1-7 shows the autocorrelation lags of wavelet 1. Note that maximum correlation occurs at zero lag, an important property of autocorrelation. Moreover, the autocorrelation function is symmetric. This is a property of real time series. Therefore, only one side of the autocorrelation needs to be computed.

It is heuristically shown in Section 1.2.4 that convolution in the time domain is equivalent to multiplication in the frequency domain (Bracewell, 1965). Since correlation is

Table 1-1. Linear superposition.

Time of Onset	Reflectivity Sequence	Source	Response
0	1 0 $\frac{1}{2}$	1	1 0 $\frac{1}{2}$
1	1 0 $\frac{1}{2}$	$-\frac{1}{2}$	$-\frac{1}{2}$ 0 $-\frac{1}{4}$
Superposition:		1 $-\frac{1}{2}$	1 $-\frac{1}{2}$ $\frac{1}{2}$ $-\frac{1}{4}$

Expressed differently:

$$(1, 0, \frac{1}{2}) * (1, -\frac{1}{2}) = (1, -\frac{1}{2}, \frac{1}{2}, -\frac{1}{4})$$

Table 1-2. Convolution of source wavelet $(1, -\frac{1}{2})$ with the reflectivity sequence $(1, 0, \frac{1}{2})$.

Reflectivity Sequence	Output Response
1 0 $\frac{1}{2}$	
$-\frac{1}{2}$ 1	1
$-\frac{1}{2}$ 1	$-\frac{1}{2}$
$-\frac{1}{2}$ 1	$\frac{1}{2}$
$-\frac{1}{2}$ 1	$-\frac{1}{4}$

Table 1-3. Mechanics of the convolutional process.

Fixed Array:

a(1) a(2) a(3) a(4) a(5) a(6) a(7) a(8)

Moving Array:

b(1) b(2) b(3)

Given two arrays, a(i) and b(j):

Step 0 = Reverse moving array b(j).

Step 1 = Multiply in the vertical direction.

Step 2 = Add the products and write as output point c(k).

Step 3 = Shift array b(j) one sample to the right and repeat Steps 1 and 2.

a convolution without reversing the moving array (see Table 1-3), a similar frequency-domain operation also applies to correlation. Figure 1-18 is a summary of frequency-domain descriptions of convolution and correlation.

From Figure 1-18, note that both convolution and correlation produce an output with a spectral bandwidth that is common to both of the input series. The immediate example is the band-pass filtering process. Also note that phases are additive in case of convolution and subtractive in case of correlation (Bracewell, 1965). For autocorrelation, this implies that the output series is zero phase. This fact already was verified by the example in Table 1-7 where it was shown that the autocorrelation is symmetric with respect to zero lag.

As a measure of similarity, crosscorrelation is used widely at various stages of data processing. For instance, traces in a common-midpoint (CMP) gather are crosscorrelated with a pilot trace to compute residual statics shifts (see Section 3.4). Again, the fundamental basis for computing velocity spectra is crosscorrelation. The building blocks of the Wiener filter (Section 2.6) are crosscorrelation of the desired output waveform with the input wavelet and autocorrelation of the input wavelet.

Table 1-4. Convolution of reflectivity sequence $(1, 0, \frac{1}{2})$ with source wavelet $(1, -\frac{1}{2})$.

Source Wavelet	Output Response
1 $-\frac{1}{2}$	
$\frac{1}{2}$ 0 1	1
$\frac{1}{2}$ 0 1	$-\frac{1}{2}$
$\frac{1}{2}$ 0 1	$\frac{1}{2}$
$\frac{1}{2}$ 0 1	$-\frac{1}{4}$

Table 1-5. Crosscorrelation of wavelet 1 with wavelet 2.

	2	1	-1	0	0	Output Lag
0	0	2	1	-1	0	-2 -4
0	0	0	2	1	-1	1 -3
0	0	0	0	2	1	6 -2
0	0	0	0	0	2	1 -1
0	0	0	0	0	2	-2 0
0	0	0	0	0	2	0 1
0	0	0	0	0	2	0 2
0	0	0	0	0	2	0 3
0	0	0	0	0	2	0 4

Table 1-6. Crosscorrelation of wavelet 2 with wavelet 1.

	0	0	2	1	-1	Output Lag
2	1	-1	0	0	0	0 -4
2	1	-1	0	0	0	0 -3
2	1	-1	0	0	0	0 -2
2	1	-1	0	0	0	0 -1
2	1	-1	0	0	0	-2 0
2	1	-1	0	0	0	1 1
2	1	-1	0	0	0	6 2
2	1	-1	0	0	0	1 3
2	1	-1	0	0	0	-2 4

Table 1-7. Autocorrelation of wavelet 1.

	2	1	-1	0	0	Output Lag
2	1	-1	0	0	0	0 -4
2	1	-1	0	0	0	0 -3
2	1	-1	0	0	0	-2 -2
2	1	-1	0	0	0	1 -1
2	1	-1	0	0	0	6 0
2	1	-1	0	0	0	1 1
2	1	-1	0	0	0	-2 2
2	1	-1	0	0	0	0 3
2	1	-1	0	0	0	0 4

One other important process is the vibroseis correlation. This involves crosscorrelation of a frequency-modulated source (sweep) signal with the recorded vibroseis trace. The sweep is a frequency-modulated vibroseis source input to the ground. The convolutional model for vibroseis data is described in Section 2.7.7. Figure 1-19 shows a vibroseis sweep signal, a recorded common-source gather, and the correlated gather. The sweep length is 10 s with a frequency band of 6 to 60 Hz. The 15-s uncorrelated vibroseis record yields a 5-s correlated record. Note that the early part of the uncorrelated

record contains low-frequency energy with increasingly higher frequencies at late times. This is because an *upsweep* (frequency increasing with time) signal was used in this data example.

1.2.4 Frequency Filtering

What happens to a wavelet when its amplitude spectrum is changed while its zero-phase character is preserved? To begin, consider the wavelet (summed trace 1) resulting from superposition of two very low-frequency components in Figure 1-20. Then add increasingly higher frequency components to the Fourier synthesis (summed traces 2 through 5). Note that the wavelet in the time domain is compressed as the frequency bandwidth (the range of frequencies summed) is increased. Ultimately, if all the frequencies in the inverse Fourier transformation are included, then the resulting wavelet becomes a spike, as seen in Figure 1-21 (summed trace 6). Therefore, a spike is characterized as the in-phase synthesis of all frequencies from zero to the Nyquist. For all frequencies, the amplitude spectrum of a spike is unity, while its phase spectrum is zero.

Figure 1-22 shows five zero-phase wavelets, synthesized as shown in Figure 1-20. Note that all of them have band-limited amplitude spectra. A zero-phase band-limited wavelet can be used to *filter* a seismic trace. The output trace contains only those frequencies that make up the wavelet used in filtering. The time-domain representation of the wavelet is the *filter operator*. The individual time samples of this operator are the *filter coefficients*. The process described here is zero-phase frequency filtering, since it does not modify the phase spectrum of the input trace, but merely band limits its amplitude spectrum.

Frequency-domain filtering involves multiplying the amplitude spectrum of the input seismic trace by that of the filter operator. The procedure is described in Figure 1-23. On the other hand, the filtering process in the time domain involves convolving the filter operator with the input time series. Figure 1-24 is a summary of the filter design and its time-domain application. The frequency- and time-domain formulations of the filtering process (Figures 1-23 and 1-24) are based on the following important concept in time series analysis: *Convolution in the time domain is equivalent to multiplication in the frequency domain. Similarly, convolution in the frequency domain is equivalent to multiplication in the time domain* (Bracewell, 1965).

Frequency filtering can be in the form of band-pass, band-reject, high-pass (low-cut), or low-pass (high-cut) filters. All of these filters are based on the same principle: construct a zero-phase wavelet with an amplitude spectrum that meets one of the four specifications. Band-pass filtering is used most because a seismic trace typically contains some low-frequency noise, such as ground roll, and some high-frequency ambient noise. The usable seismic reflection energy usually is confined to a bandwidth of approximately 10 to 70 Hz, with a dominant frequency around 30 Hz.

Band-pass filtering is performed at various stages in data processing. If necessary, it can be performed before

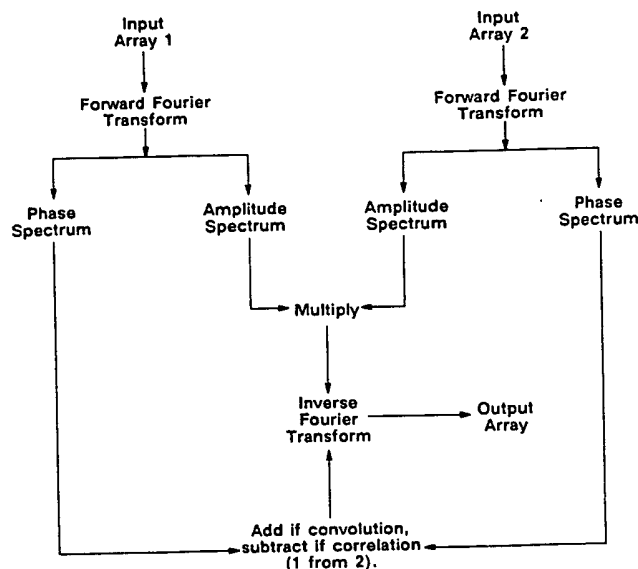


FIG. 1-18. The frequency-domain description of convolution and correlation.

deconvolution to suppress remaining ground roll energy and high-frequency ambient noise that otherwise would contaminate signal autocorrelation. Narrow band-pass filtering may be necessary before crosscorrelating traces in a CMP gather with a pilot trace for use in estimating residual statics shifts (Section 3.4). Band-pass filtering also can be performed before computing crosscorrelations during construction of the velocity spectrum for improved velocity picking (Section 3.3). Finally, it is a standard practice to apply a time-variant band-pass filter to stacked data (this section).

Practical Aspects of Filter Design

Application of a filter in the frequency or time domain (Figures 1-23 and 1-24) yields basically identical results. In practice, the time-domain approach is favored, since convolution involving a short array, such as a filter operator, is more economical than doing Fourier transforms.

From Figure 1-22, the fundamental property of frequency filters can be stated as: *The broader the bandwidth, the more compressed the filter operator; thus, fewer filter coefficients are required.* This property also follows from the fundamental concept that the effective time span of a time series is inversely proportional to its effective spectral bandwidth (Bracewell, 1965).

In designing a band-pass filter, the goal is to pass a certain bandwidth with little or no modification, and to largely suppress the remaining part of the spectrum as much as practical. Initially, it appears that this goal can be met by defining the desired amplitude spectrum for the filter operator as follows:

$$A(f) = \begin{cases} 1, & f_1 < f < f_2 \\ 0, & \text{elsewhere,} \end{cases}$$

where f_1 and f_2 are the cutoff frequencies. This is known

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